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METHODS AND COSTS OF CONCENTRATING HÜBNERITE ORES AT THE IMA TUNGSTEN MINE, LEMHI COUNTY, IDAHO

BY

C. M. DICE

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METHODS AND COSTS OF CONCENTRATING HÜBNERITE ORES AT THE IMA TUNGSTEN MINE, LEMHI COUNTY, IDAHO[1/]

By C. M. Dice[2/]

INTRODUCTION

This paper is one of a series being published by the Bureau of Mines on milling methods and costs. It describes briefly the procedure followed in concentrating hübnerite ore at the Ima tungsten mine, Lemhi County, Idaho.

In October 1941 the Ima mill was utilizing combined gravity-concentration, flotation, and magnetic-separation units for the recovery of a tungsten concentrate and a pyritic silver concentrate. Approximately 120 tons of ore averaging 0.5 percent WO_3 is treated daily. The concentrates produced average 66 to 67 percent WO_3.

ACKNOWLEDGMENT

The author wishes to express his indebtedness to W. P. Barton, manager of the Ima Mines Corporation, for permission to publish this paper.

LOCATION

The mine and mill of the Ima Mines Corporation are situated slightly more than a mile east of the small settlement of Patterson in Lemhi County, Idaho. Concentrates and supplies are transported by truck to and from Mackay, Idaho, which is the nearest railroad shipping point. The distance from the mine to Mackay is 60 miles by summer road over Double Springs Pass, or 100 miles by winter road via Ellis and Challis.

1/ The Bureau of Mines will welcome reprinting of this paper providing the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular, 7230."

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The mill is adjacent to the mine portal and is on the north side of the narrow, steeply walled canyon of Patterson Creek, 1 mile above the junction of Patterson Creek and the Pahsimeroi River. Although the mine is 6,300 feet above sea level, in a mountainous region, it may be reached on water grade.

POWER

Two caterpillar Diesel engines, one D-13000 and one D-1700, belted to a common line shaft furnish the power for milling operations.

During the summer months a 2-mile flume delivers water to a small Pelton wheel connected by belt and pulley to the mill line shaft. The Pelton wheel generates 65 to 70 horsepower and can replace one Diesel engine.

The crusher, sand pump, ball mill, and four cells of the sulfide flotation unit are belt-driven directly from the line shaft. One 60 kv.-a. and one 25-kv.-a., 110-volt, direct-current generator also are driven from the line shaft. The generators furnish power for the separators, lighting circuit, mine-locomotive-battery charging panels, and the individual motors required to drive the rest of the milling equipment. A 3-horse-power, d. c. motor drives a small 25-cycle alternating-current generator, which serves the vibrating screens.

WATER SUPPLY

An adequate supply of water for milling operations is obtained from Patterson Creek, which flows alongside and 20 feet below the lower floor of the mill building. During the winter months, when freezing weather does not permit use of the flume supplying water to the Pelton wheel, the water for concentrating purposes is pumped from the creek to the mill supply-head tank on the top floor of the mill building. In the summer, water for concentrating is taken from the flume ahead of water to the Pelton wheel.

ORE TREATED

The ore bodies at the Ima mine are quartz veins that vary in width from a few feet to 20 feet or more. The average stoping width is approximately 5 feet. The veins occur in quartzite near its contact with granite intrusives. Some ore is found within the granite. All stoping is by square-set methods.

The ores milled vary widely in their metallic content, gangue constituents, and physical characteristics. The gangue of the ore received at the mill is predominantly quartz, with varying amounts of fluorite, rhodo-

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chrosite, mica, talc, and pyrite. The ore minerals are hübnerite, silver-bearing tetrahedrite, galena, chalcopyrite, sphalerite, and molybdenite. A typical analysis of the mill head follows:

	Percent
Au	Trace
Ag	1.85
Cu	.2
Pb	.25
Fe	2.6
Insoluble	88.2
Zn	.2
S	2.1
WO_3	.52
MoS_2	.1

For the most part, the hubnerite occurs in relatively large crystals, which break cleanly from the enclosing quartz during grinding. An important quantity of more finely disseminated hubnerite does occur, however, requiring that the ore be given a final regrind to approximately 40-mesh before economical liberation can be effected. The principal problem faced in milling this ore is the liberation of minerals from the gangue without undue sliming of the tungsten mineral. The hübnerite is brittle and will readily shatter to thin, platy slimes, which it is virtually impossible to recover by gravity methods, the principal concentrating means employed. At times, particularly when appreciable mining is being done along the granite contacts, the hübnerite occurs as soft, semidecomposed crystals, which break down to slimes upon the addition of water. This condition is accompanied by greater quantities of talc and altered argillite, which greatly aggravate the slime problem. As shown in table 1, the proportion of minus-200 mesh product may be as much as 13 percent of the total mill feed owing to the receipt of ores from the crushed contact zones. Screen analyses of the dry, crushed materials, as delivered to the mill bin, are given in tables 1 and 3.

TABLE 1. - Screen analysis of typical mill feeds

Mesh	Sample 1, weight, percent	Sample 2, weight, percent
+6	82.2	23.4
-6 + 20	7.5	35.5
-20 + 48	3.3	12.0
-48 + 100	1.5	11.2
-100 + 200	1.3	4.9
-200	4.2	13.0

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HISTORY OF THE IMA MILL

The Ima property was operated for the production of tungsten concentrates during World War I but was shut down shortly thereafter when the price of tungsten made further operations unprofitable. Records of mill operation during that period are meager. The flow sheet is believed to have consisted of primary crushing in a Blake-type crusher followed by secondary crushing with Wall corrugated rolls, which discharged into hydraulic classifiers. These, in turn, were operated in closed circut with secondary rolls. The classifier overflow at approximately 12-mesh constituted the finished grind. Concentration was by means of Harz jigs and Wilfley tables. A recovery of approximately 25 percent was obtained, and a concentrate averaging 45 to 50 percent WO_3 was produced.

Since the property was reopened by the present management, the flow sheet has been modified a number of times to take advantage of information gained from the large amount of test work done. The mill was converted entirely to flotation for a short time, but because of the impossibility of maintaining duplicate circuits, the plan was abandoned in favor of the advantages offered by tables. The table operation produced a concentrate containing 50 to 55 percent WO_3. It was difficult, however, to maintain a recovery greater than 50 percent. The addition of jigs to the grinding circuit and of magnetic separators for treating the low-grade jig and table concentrates resulted in the production of a finished concentrate containing more than 66 percent tungstic acid. Recoveries of 60 to 65 percent were obtained. Approximately 85 percent of the total recovery was effected with the jigs, the tables acting as scavenging units for the recovery of some slimed material.

The flow sheet was revised recently to provide for the treatment of a larger tonnage of ore and at the same time effect a greater saving of the slimed minerals. Classification capacity was increased by the addition of screens placed in the grinding circuit in a series arrangement with the existing Dorr classifier. The jig tailing carrying the slimed portion of the tungsten minerals and assaying 0.20 to 0.25 percent WO_3 is now given a preliminary concentration treatment by flotation. The concentrate produced is treated further on a table before being subjected to magnetic separation.

PRESENT MILL PRACTICE

Figure 1 is the flow sheet of milling operations as now practiced. A description of it follows:

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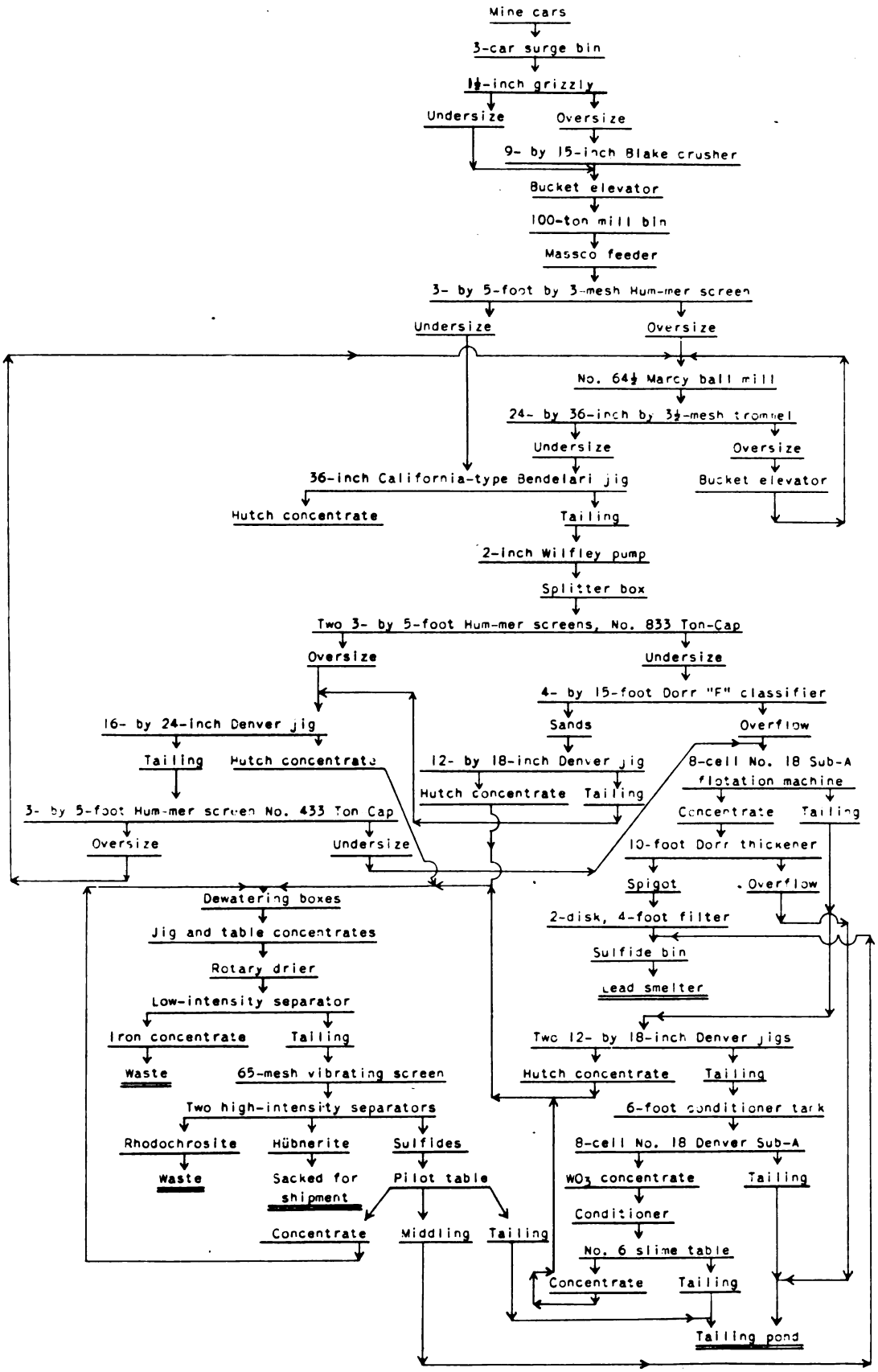

Figure 1.- Flow sheet of Ima mill.

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Crushing

Ore is received at the mill in trains of six to eight mine cars of 16-cubic-foot capacity. No primary storage is provided; the cars are dumped directly onto an 8-inch horizontal, rail grizzly, which covers a small surge bin of two- to three-car capacity. Oversize lumps are broken by hand through the grizzly.

The bottom of the surge bin is formed by a grizzly set on a 35° slope with bars spaced 1-1/2 inches. From the surge bin the ore is fed by hand to a 9- by 15-inch Blake-type jaw crusher set to 1-1/2 inches. The crusher is operated a full three shifts, as it must be coordinated with mine delivery. The ore shatters readily, and the crusher has a capacity of 225 cars per 24 hours. The crusher discharge joins the grizzly undersize and is delivered to a 100-ton mill bin by means of a bucket elevator driven from the extended crusher shaft.

Grinding and Classification

An adjustable-stroke feeder delivers the ore from the mill bin to a 3- by 5-foot, 3-1/2-mesh vibrating screen. The oversize is fed to the ball mill, and the undersize is laundered to a 36-inch, single-cell Bendelari jig. The ball mill discharges through a 24- by 36-inch spiral screen equipped with a 3- by 3-mesh steel cloth. Screen oversize is elevated and returned to the ball mill, while the undersize joins the primary screen undersize at the Bendelari jig.

The grinding unit consists of a No. 64-1/2 Marcy ball mill equipped with 3/8- by 1/2-inch compensating grates and operates in closed circuit with vibrating screens and a 15- by 4-foot Dorr "F" classifier. At present the ball mill receives about 120 tons of ore a day from the storage bin. The return to the ball mill, consisting of spiral-screen oversize, vibrating-screen oversize, and screened classifier sands, amounts to approximately 200 tons a day. The mill operates at a speed of 26 r.p.m. and is driven from the main mill line shaft by a V belt connected with the ball-mill pinion shaft through a No. 20 Lemley clutch.

The ball mill is operated with a comparatively low pulp density ranging from 55 to 60 percent solids. Manganese-steel breast liners, and liners, and grates are used. A relatively light ball load is maintained, averaging 6,000 to 7,000 pounds. Ball wear is compensated by the addition of 4-inch, hardened forged-steel balls. Under these operating conditions the consumption of steel per ton of initial feed is relatively high, being approximately as follows:

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	Steel consumption, pounds per ton of initial feed
4-inch forged-steel balls	2.25
Breast liners	.40
End liners	.05
Grates	.03
	2.73

Chilled cast balls have been tried. However, breakage was high and the accumulation of ball iron on the jigs caused blinding of the beds and rendered use of balls, of this type uneconomical. Between 6 and 7 pounds of chilled cast-type ball was consumed per ton of ore.

The classification flow sheet, which may appear unduly complex, was designed, first, to eliminate as far as possible overgrinding of tungsten minerals and, second, to deliver prepared feeds to the jigs, rather than for mere removal of finished sands. Screen classification is used to minimize overgrinding of heavy mineral particles of finished size, which inevitably occurs when hydraulic classifiers alone are used.

Comparison of the type of grind obtained from three different classification flow sheets is given in tables 2, 3, and 4. Table 2 gives screen analyses of ball-mill discharge, ball-mill return, and mill tailings when No. 166 (35-mesh) Ton-Cap screen classification is used. In table 3 columns 4, 9, and 11 contain percentages corresponding to those in figure 2 when a combined screen and hydraulic classification, as employed in the present flow sheet, is used. Table 4 gives the screen analyses of classifier sands and mill tailings when the classifier alone was operating in closed circuit with the ball mill.

TABLE 2. - Screen Analysis of mill products using screen classification

Mesh, size	Percent Weight		
	Discharge	Return	Tailings
+ 8	9.2	20.5	--
-8 + 20	15.9	34.1	--
-20 + 48	28.4	41.7	13.1
-48 + 65	7.6	1.3	15.1
-65 + 100	6.1	.4	12.8
-100 + 200	10.4	.5	20.2
-200	22.4	1.5	38.8

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TABLE 3. - Screen analyses of mill products, percent by weight, each size

Point, as indicated in flow sheet, at which the sample was taken											
Mesh	(1) Mill feed	(2) Primary screen over-size	(3) Primary screen under-size	(4) Second-ary screen feed	(5) Second-ary screen over-size	(6) Classi-fier feed	(7) Classi-fier over-flow	(8) Classi-fier sands	(9) Ball-mill return	(10) 35-mesh screen under-size	(11) Mill tailings
+0.742"	36.9	54.3	-	-	-	-	-	-	-	-	-
-.742"+.525"	9.4	12.2	-	-	-	-	-	-	-	-	-
-.525"+.371"	10.6	12.5	-	-	-	-	-	-	-	-	-
-.371"+.3M	8.6	10.0	-	-	-	-	-	-	-	-	-
-3 + 4	6.8	6.1	-	0.4	2.0	-	-	-	0.8	-	-
-4 + 6	4.8	3.3	3.3	2.8	7.3	-	-	-	5.1	-	-
-6 + 8	4.2	.5	17.3	4.1	12.4	-	-	-	9.0	-	-
-8 + 10	3.2	.2	13.3	4.6	11.6	-	-	-	9.6	-	-
-10+ 14	2.7	.9	13.3	5.4	13.7	-	-	-	11.0	-	-
-14+ 20	2.0	-	9.6	5.6	13.4	1.1	-	1.3	11.8	-	-
-20+ 28	1.9	-	8.5	9.3	13.9	8.0	-	9.0	19.7	0.6	0.4
-28+ 35	1.4	-	5.6	10.5	9.2	12.3	0.5	17.9	17.6	8.5	5.7
-35+ 48	1.6	-	3.3	9.0	3.9	11.3	.5	22.6	7.4	17.7	11.6
-48+ 65	1.5	-	1.1	5.9	.5	7.2	1.3	17.0	2.1	14.1	9.7
-65+100	.9	-	6.9	10.0	3.8	16.0	7.0	12.7	3.3	25.0	18.6
-100+150	.5	-	2.4	5.0	1.0	6.9	8.3	8.4	.7	9.7	9.2
-15-+200	.9	-	2.2	5.0	1.0	6.6	12.6	4.1	.4	6.5	8.7
-200	2.1	-	13.2	22.4	6.3	30.6	69.8	7.0	1.5	17.9	36.1

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TABLE 4. - Sieve analysis of classifier products (former practice)

Mesh size	Classifier sands, weight, percent	Mill tailing, weight, percent
+ 40	39.8	1.0
-40 + 60	19.8	6.0
-60 + 80	16.2	13.5
-80 + 100	2.3	2.5
-100 + 150	9.2	16.0
-150 + 200	4.3	15.0
-200	8.4	46.0

The Bendelari jig tailings are pumped to the top floor of the mill building and discharged into a splitter box, which divides the feed between two secondary screens. 3- by 5-foot Hum-mer screens equipped with No. 833 Ton-Cap stainless-steel cloth having openings 0.047 inch in width (14-mesh) are used at this point. Undersize from the screens discharges into a 15- by 4-foot Dorr type-F classifier, whereas the oversize is laundered to a 16- by 24-inch, two-compartment Denver jig. The classifier, which operates principally to deslime the fine jig sands, is set on a slope of 3 inches per foot and operates at a speed of 28 r.p.m. Classifier overflow, which averages about 15 percent solids, is laundered to the first cell of the sulfide flotation unit. Classifier sands are passed over a 12- by 18-inch, two-compartment Denver jig and then join the oversize from the secondary screen at the large Denver jig. Tailings from this jig are screened on a 3- by 5-foot Hum-mer equipped with No. 433 Ton-Cap stainless-steel cloth having openings 0.021 inch in width (30-mesh). The screen oversize is returned to the ball mill, whereas the screen undersize is pumped to the third cell of the sulfide flotation machine. Screen efficiencies range from over 90 percent with a new screen cloth to about 75 percent just before replacement of the cloth. Sieve analyses of various products from the grinding unit are given in table 3.

Jigging

Most of the tungsten recovered from the ore is obtained on the primary jigs included in the grinding circuit. The ball-mill discharge, after removal of the plus-3-mesh material, is treated in a 36-inch, California-type Bendelari jig. The jig is operated at 150 r.p.m., using a 5/8-inch stroke. Most of the plus-20-mesh hübnerite, as well as a considerable portion of the plus-200-mesh mineral, is recovered at this point. The concentrate averages between 36 and 40 percent WO_3. Pyrite is largely rejected. Tailings from this jig are screened on 20-mesh, and the undersize

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is deslimed and jigged again. At this point the classifier serves the double purpose of removing excess water and minus-150-mesh gangue while allowing fine tungsten to concentrate in the sands. The sands are then jigged on a small, two-compartment Denver jig operating at 300 r.p.m. with a 3/16- to 1/8-inch stroke. Tailings from this jig are used to dilute the plus-20-mesh sands for jigging on the 16- by 24-inch Denver jig. A speed of 200 r.p.m. with a 1/4-inch stroke is used on this unit. The concentrate produced from the 16- by 24-inch Denver jig consists mainly of coarse pyrite and assays 12 to 20 percent WO_3. Minus-40-mesh sands are then removed by screening before returning the sands to the mill for further grinding. Two small secondary jigs treat the tailings from the sulfide flotation machine and account for approximately 15 percent of the total jig recovery. Over-all jig recovery amounts to approximately 65 percent of the original mill-feed content. All primary jig concentrates are combined at the dewatering box and produce a concentrate containing 20 to 30 percent WO_3, which is concentrated to shipping grade by magnetic separation.

Flotation

Classifier overflow and screen undersize at a pulp density of approximately 20 percent solids is subjected to a bulk sulfide flotation to recover a silver concentrate consisting principally of pyrite. The sulfide unit consists of an 8-cell No. 18 Denver Sub-A machine, the original bank of four cells, and a later addition of two motordriven units of two cells each. The original bank of four cells is belt-driven from the line shaft. The first two cells produce a finished concentrate, and the succeeding six cells produce a rougher concentrate, which is returned to the first cell by gravity. Reagents used in this section are 0.15 pound per ton isopropyl xanthate and 0.10 pound per ton pine oil. Reagents are added to the classifier overflow feeding into the first cell of the flotation machine.

The sulfide concentrate produced after thickening and filtering is combined with the sulfide tailings from the magnetic separators and shipped to a lead smelter. The combined product assays as follows:

	Percent
Au (ounce)	0.01
Ag (ounces)	45.0
Cu	3.8
Pb	7.0
Insoluble	9.0
Fe	29.2
Zn	4.8
S	37.6

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Tailings from the sulfide unit are divided equally to two 12- by 18-inch Denver jigs. The reagent for the flotation of slimed tungsten is added to the tailings from these jigs, which discharge into a 6-foot conditioning tank at a density of 15 percent solids. The reagent is composed of an emulsion containing:

	Pound per ton
Oleic acid	0.25
Reagent No. 708	.30
Emulsol X-1	.05

Cost of this reagent averages 4.2 cents per ton of original mill feed.

A second 8-cell, No. 18, Denver Sub-A machine is used for the flotation of slimed tungsten. The froth removed from this unit assays 4 to 6 percent WO_3, the remainder being chiefly fluorite, sericite, and rhodochrosite. Tailing from this flotation unit carries only traces of tungsten and is sent to the tailings pond. The concentrate is conditioned with sulfuric acid added at the rate of 0.5 pound per ton of ore to break down the froth; the concentrate is then tabled on a No. 6 Deister-Overstrom diagonal-deck slime table equipped with rubber deck and riffles for the rejection of fluorite and rhodochrosite. A product containing 25 or 30 percent WO_3 is thus obtained from the slimed flotation concentrate with a recovery of 50 to 55 percent. Table tailings carrying 1 to 2 percent WO_3 join the flotation tailings and are laundered to the tailing ponds. Assay of the combined tailings shows 0.07 to 0.10 percent WO_3 and 0.2 to 0.25 ounce silver per ton. Elutriation tests indicate that most of the tungsten content of the tailing is in the minus-400-mesh product and more than 50 percent is in the minus-800-mesh portion.

Magnetic Separation

Magnetic separation of the flotation concentrate instead of the tabling operation is not feasible because of the large amount of rhodochrosite present, which has approximately the same magnetic susceptibility as the hübnerite.

A screen analysis of separator feed is given in table 5. The various jig and table concentrates produced are accumulated in dewatering boxes and dried at the end of the day in a small rotary tube furnace. The furnace consists of a sheet-iron cylinder 18 inches in diameter and 15 feet in length set at a slope of 2 inches a foot. Material to be dried is fed by means of a scoop feeder and is discharged onto a concrete floor, from which it is shoveled to storage bins. After cooling for 24 hours, the dried concentrate is treated on the magnetic separators.

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TABLE 5. - Screen analysis of separator feed

Mesh	Primary jig, screen oversize		Primary jig, screen undersize		Secondary jig, screen oversize		Secondary jig, screen undersize		Table	
	weight, percent	WO_3, percent	weight, percent	WO_3, percent	weight, percent	WO_3, percent	weight, percent	WO_3, percent	weight, percent	WO_3, percent
+ 14	9.5	11.05	-	-	-	-	-	-	-	-
-14 + 20	13.2	13.30	-	-	-	-	-	-	-	-
-20 + 48	55.5	18.80	3.8	15.94	51.8	7.06	-	-	-	-
-48 + 100	17.1	24.13	35.0	23.76	46.8	14.46	45.1	24.92	2.2	6.45
-100 + 200	4.7	21.90	42.4	25.50	1.4	44.92	48.4	48.36	43.0	18.95
-200	-	-	18.8	30.26	-	-	6.5	34.52	54.8	33.23
Total	100.0	18.30	100.00	25.25	100.0	11.02	100.0	36.86	100.0	26.54

Dust from the drying furnace is caught in a baffled settling chamber and periodically treated at the magnetic separators. Six to eight hundred pounds per month of high-grade tungsten dust is recovered from this source.

Three magnetic separators are used in the final cleaning of the jig and table concentrates. One low-intensity machine removes circuit iron plus any partly roasted pyrite that may have been formed in the drying operation. A small vibrating screen is attached to the discharge of this machine and removed the minus-80-mesh material for separate treatment. Two Dings, type-E, two-pole separators treat the screened portions of the concentrates to remove finished tungsten concentrate. The first machine, with a belt width of 12 inches, draws 16 to 18 amps.; whereas the second, with a belt width of 24 inches, draws 32 to 38 amps.

The pole gaps are adjusted to conform to the size of the material being treated and to the impurities present. For those concentrates that carry considerable rhodochrosite and siderite, the gap on the first pole is widened, and these impurities are removed ahead of the tungsten. The feed rate is governed by the appearance of the streak on the pilot table, to which all separator tailings are fed. In general, a feed rate of approximately 250 pounds per hour per foot of belt width is used on the plus-65-mesh feed, while rates somewhat less than half this are required for the minus-65-mesh portions. Screen analysis of WO_3 concentrates for the various products fed to the magnetic separators is shown in table 6. A small cut is removed from the pilot table and returned to the magnetic separators, accounting for approximately 1 percent of the total amount of tungsten produced.

The over-all recovery at the separator units ranges from 95 to 97 percent, virtually complete recovery being obtained on the plus-100-mesh feeds. Final concentrate is sacked in paper-lined canvas bags of 100 pounds capacity.

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TABLE 6. - Screen analysis of WO_3 concentrate fed to magnetic separators

Mesh	Weight, percent
+ 8	1.0
- 8 + 14	6.1
-14 + 20	6.0
-20 + 35	17.0
-35 + 48	11.0
-48 + 65	13.1
-65 + 100	10.6
-100 + 150	10.6
-150 + 200	8.6
- 200	16.0

PUMPING

The 3-mesh trommel undersize is pumped at 40 percent solids against a 45-foot head to the secondary screens by means of a 2-inch Wilfley pump equipped with rubber wearing parts. This service is quite severe, and life of a runner ranges from 4 to 6 weeks. Ni-hard runners tested under the same service had an operating life of 8 days. A second 2-inch Wilfley pump delivers the minus-40-mesh sand from the screen to the flotation circuit. Wear on this pump is negligible, an impellor life of more than a year being indicated.

METALLURGICAL DATA

A summary of metallurgical results for a representative period is given in table 7.

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TABLE 7. - Metallurgical data for first 12 weeks in 1941

Ore treated	tons	8,659
Time operated	days	77
Sulfide concentrate produced	tons	303
Tungsten concentrate produced	pounds	109,220
Ratio of concentration (tungsten concentrate)		158:1
Ratio of concentration (sulfide concentrate)		29:1
Percent of total WO_3 concentrate recovered at:		
Primary jigs		68.07
Secondary jigs		11.53
Table (flotation)		18.33
Retable and dust		2.07
Average assay of mill heads, WO_3,	percent	.53
Average assay of mill tails WO_3,	percent	.08
Average assay of concentrates WO_3,	percent	67.1
WO_3 recovered per ton ore	pounds	8.45

LABOR DISTRIBUTION

The mill employs 20 men each day, including a carpenter, 3 mechanics, and 2 men on tailings disposal. More men are employed than in the average mill treating the same tonnage, but the number of operations required to treat the ore make this necessary. The mechanical crew also takes care of the mine compressor plant, repairs to mine hoists and pumps, and miscellaneous mine repairs. A summary of the wage and labor follows:

Job	Shifts per day	Rate per day	Total amount
General foreman	1	$6.25	$ 6.25
Shift foreman	3	5.00	15.00
Shift repairman	3	5.00	15.00
Carpenter	1	5.00	5.00
Crusher	3	4.00	12.00
Jig	3	4.50	13.50
Separator	3	4.50	13.50
Drier	1	4.00	4.00
Tailings dike	2	4.00	8.00
Total	20		92.25

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COSTS

Following is a summary of operating costs for a representative period:

TABLE 8. - Summary of milling costs, first 6 months in 1941, 19,887 tons

		Cost per ton dry ore milled	
Direct charges:			
Labor		$0.795	
Supplies:			
Grinding balls	0.090		
Reagents	.158		
Other	.098		
	.346	.346	
Power		.326	
Maintenance		.204	
Total direct		1.671	$1.6710
General operating charges (distributed):			
Administration and office		0.3125	
Trucking (including depreciation)		.0965	
Miscellaneous expense		.0600	
Depreciation		.3720	
Total		.8410	.8410
Total operating cost			2.5120
Insurance, taxes, depletion (distributed):			
Insurance		0.2672	
Social Security taxes		.0526	
Interest		.0220	
Depletion and amortization		.0215	
Total		.3633	.3633
Total cost per ton milled			2.8753

TABLE 9. - Summary of costs in units of labor, power, and supplies, first 6 months, 1941, 19,887 tons

	Tons per man per 8-hour shift	Man-hours per ton
A. Labor:		
Breaker	32	0.250
Crusher, jigs, flotation	32	.250
Separator	32	.250
Drier	96	.083
Tailings	48	.166
Repairs and maintenance	24	.333
	6	1.332

B. Power: 22 kw.-hr. per ton or 19.5 percent of total direct cost.
C. Reagents: 0.85 lb. per ton mine-run ore.
D. Balls, liners grates: 2.73 lb. per ton mine-run ore.
E. Other supplies: 7.2 percent labor, power, reagents, steel.

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